Chapter 8

Shoulder Girdle: Clavicle and Scapula

The departure of fishes from their aquatic habitat brought profound changes in locomotion. The forelimb girdle (shoulder girdle), originally attached to the rear of the head, detached and moved tailward, leaving a flexible neck. As this girdle moved caudally, some of the head's dermal armor and gill muscles remained attached to it, and as a result our own shoulder girdle is still attached to the skull by derivatives of some of these primitive gill muscles. The remaining dermal bone element constitutes part of our clavicle. The human shoulder girdle provides support and articulation for the humerus and anchors a variety of muscles. The function of the clavicle as a strut for the shoulder is made obvious when fracture of this bone is accompanied by an anteromedial collapse of the shoulder. The shoulder girdle embraces the thorax posteriorly, laterally, and anteriorly, providing a platform for movements of the forelimb.

8.1 Clavicle (Figures 8.1–8.5, 8.10)

8.1.1 Anatomy (Figures 8.1–8.5)

The clavicle is a tubular, somewhat S-shaped bone. Its medial end (sternal extremity) articulates, via a synovial joint, with the clavicular notch of the manubrium. Its lateral end (acromial extremity) articulates with the acromial process of the scapula. The clavicle is oval-to-circular in cross section (see cross sections in Chapter 14). The medial end is rounded and flared like a trumpet, and the lateral end is flattened superoinferiorly. This element is easily palpated along its length in a living person.

a. The **sternal end** of the clavicle is stout and round and has an articular surface on its medial surface (for the manubrium) as well as a small facet lipping over onto the inferior surface (for the first costal cartilage).
b. The **acromial end** of the clavicle is flatter and wider than the sternal end. On its lateral surface is the **acromial facet**, for articulation with the acromial process of the scapula.
c. The **costoclavicular** (or **costal**) **tuberosity** (or **impression**) is a variable trait (see Section 8.1.6) on the inferior surface of the sternal end of the clavicle. When present, it is a broad, irregularly roughened surface that anchors the *costoclavicular ligament*, which strengthens the sternoclavicular joint.

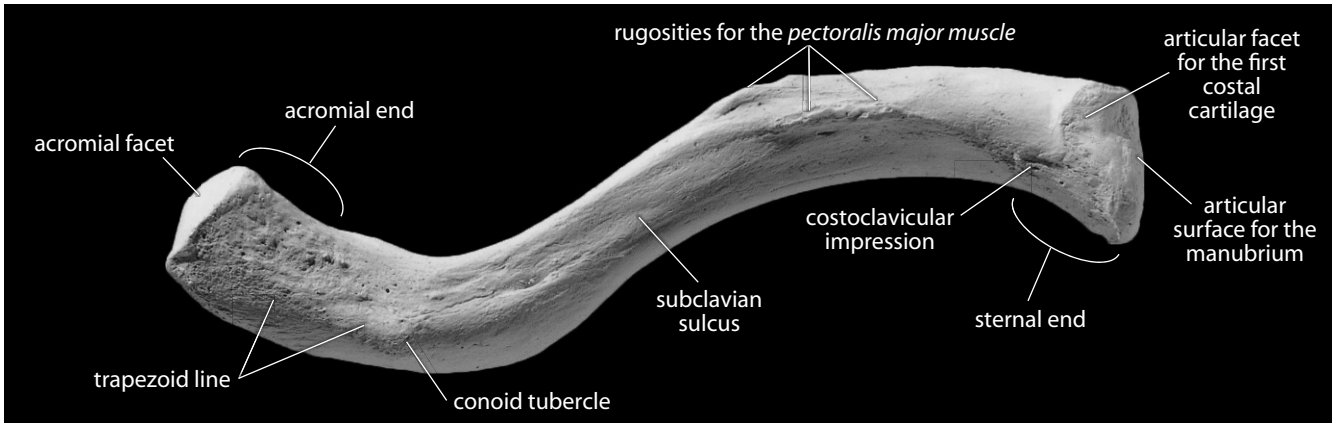

Figure 8.1 **Right clavicle, inferior.** Anterior is up, lateral is toward the left. Natural size.

d. The **subclavian sulcus** (or **groove**) runs along the posteroinferior quadrant of the midshaft, providing a roof over the great vessels of the neck and an insertion for the *subclavius muscle* between the clavicle and the rib cage. In the case of a fracture, the *subclavius* protects these vessels by preventing motion in the free end of the jagged fractured bone.

e. The **conoid tubercle** is found on the lateral end (acromial extremity) of the clavicle, and is located posteriorly. It is the attachment point for the *conoid ligament*, which attaches to the coracoid process of the scapula and reinforces the joint between these two bones.

f. The **trapezoid line** (or **oblique ridge**) leads laterally from the conoid tubercle. It is the attachment site for the *trapezoid ligament*, which functions like the *conoid ligament*.

g. The **nutrient foramen** lies along the posteroinferior edge of the bone and exits the bone medially.

h. The **superior surface** of the clavicle bears somewhat less relief than the inferior surface, despite serving as the site of attachment of three major muscles (detailed below).

i. The **rugosity for the *trapezius muscle*** can be seen along the posterolateral portion of the superior surface.

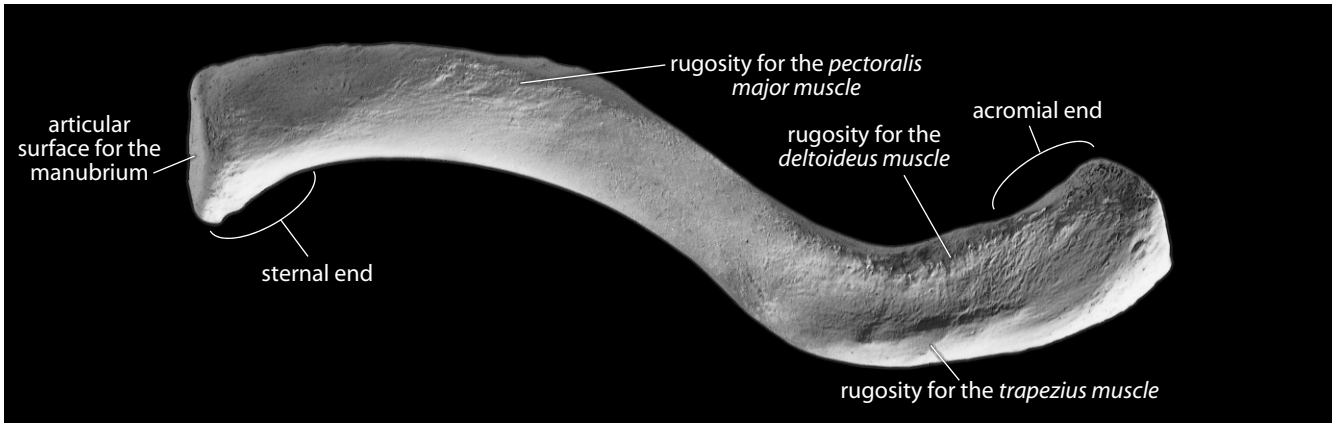

Figure 8.2 **Right clavicle, superior.** Anterior is up, lateral is toward the right. Natural size.

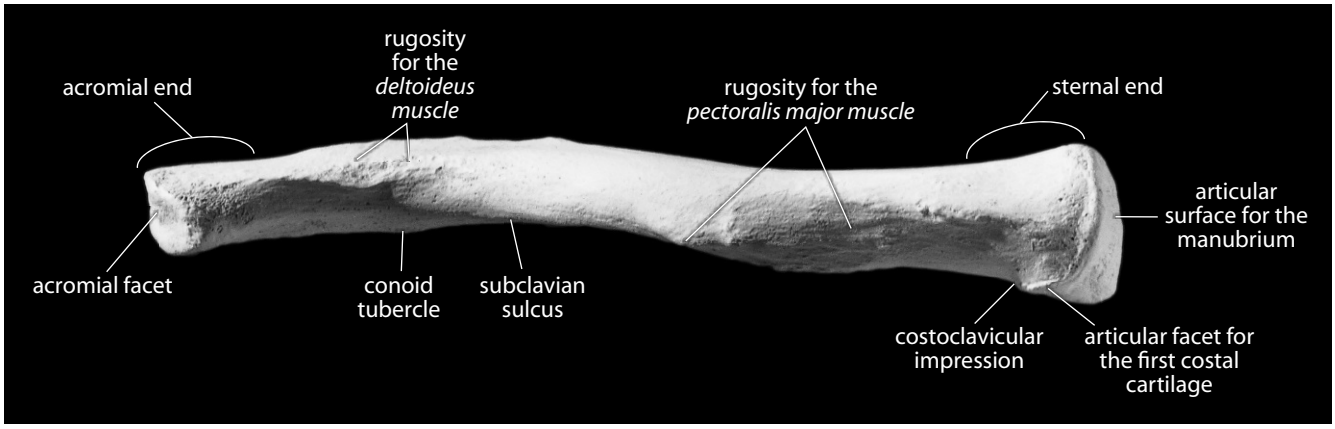

Figure 8.3 **Right clavicle, anterior.** Superior is up, lateral is toward the left. Natural size.

j. The **rugosity for the *deltoideus muscle*** is found on the anterolateral margin of the superior surface.

k. The **rugosity for the *pectoralis major*** anchors part of this muscle and marks the anteromedial portion of the clavicle.

8.1.2 Growth (Figure 8.10)

The clavicle is unusual in having two, quite different, primary centers of ossification, hinting at its complex developmental origin. The lateral half of the bone develops intramembranously (like cranial vault bones), explaining the flatter appearance of the acromial end and the lack of a distal epiphysis. The medial half of the bone is preformed in cartilage (like long bones), and develops endochondrally, with a tubular appearance, and a medial epiphysis. The bone is of additional developmental interest because it is the first to ossify *in utero* at week 5. It is also the last bone to fuse, on the sternal end, at 20–25 years of age.

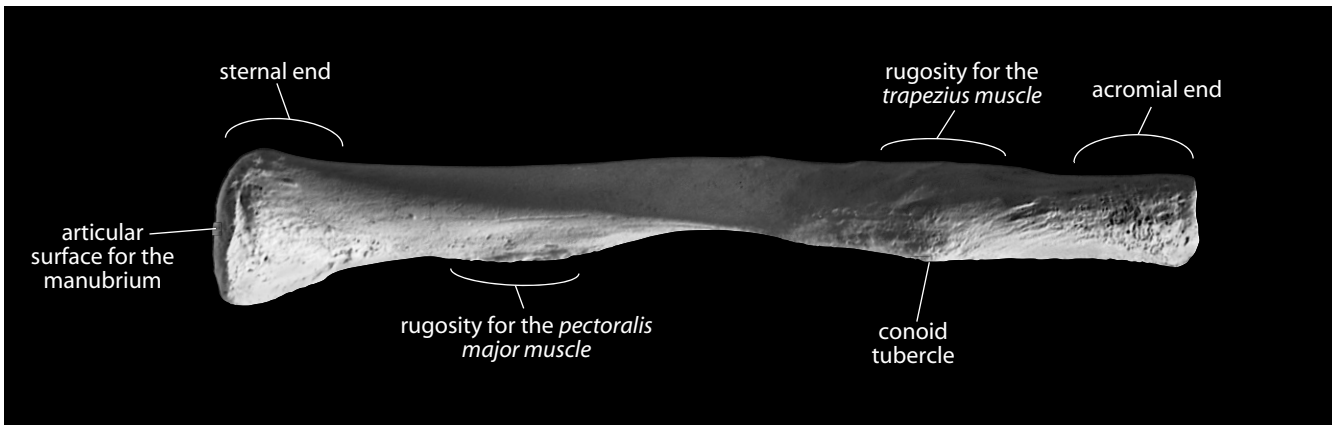

Figure 8.4 **Right clavicle, posterior.** Superior is up, lateral is toward the right. Natural size.

8.1.3 Possible Confusion

The lateral end of the clavicle is most often mistaken for the acromial process of the scapula in fragmentary specimens.

- The acromion of the scapula continues medially to become the scapular spine, whereas the lateral end of the clavicle becomes increasingly cylindrical as the shaft stretches medially.
- In comparisons of the tips of each bone, the facet of the clavicle is lateral and the facet of the acromion is anteromedial.

8.1.4 Siding

The following criteria should be sufficient to correctly side fragments of clavicle:

- The medial end is round; the lateral end is flattened.
- The bone bows anteriorly from the medial end, curves posteriorly at midshaft, and then sweeps anteriorly again as it reaches the lateral, flattened end. Thus, the apex of the first of the two curves which give the clavicle its S-shape is medial, and the apex of the second curve is lateral.
- Most irregularities and roughenings are on the inferior surface.
- The facet for the first costal cartilage is on the inferior edge of the medial clavicle, and the costal tuberosity is also inferior.

8.1.5 Clavicular Measurements (Figure 8.5)

The following are the most commonly taken and useful measurements of the clavicle:

1. **Maximum clavicular length** (Martin, 1928: 1005, #1; Buikstra and Ubelaker, 1994: 79, #35): Using an osteometric board, measure the greatest distance between the sternal and

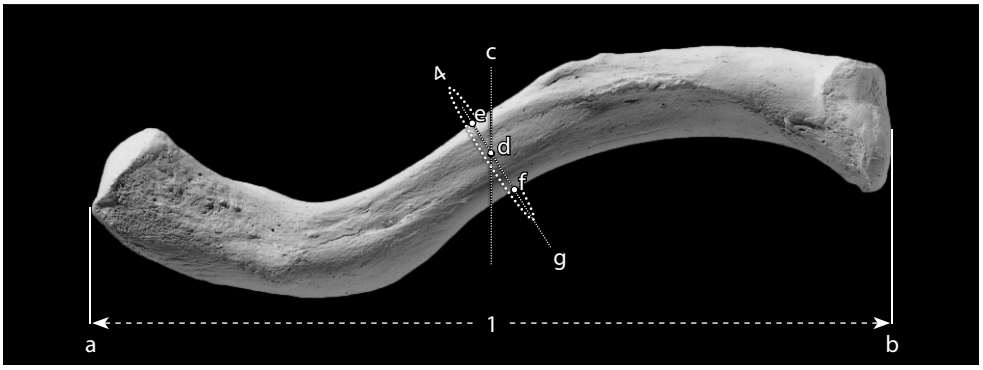

Figure 8.5 **Clavicular measurements.** Four-fifths natural size.

Locations: a) lateralmost point on acromial end; b) medialmost point on sternal end; c) midshaft (50% of maximum clavicular length); d) anteroposterior midpoint of 'c'; e) point on ventral surface that is closest to 'd'; f) point on dorsal surface that is closest to 'd'; g) line passing through 'e' and 'f'.

Measurements: 1) maximum clavicular length; 2) 'anteroposterior' midshaft diameter (*not shown, but measured along line 'g'*); 3) clavicular superoinferior midshaft diameter (*not shown, but measured along line 'g'*); 4) clavicular midshaft circumference.

acromial ends of the bone.

2. **Clavicular "anteroposterior" midshaft diameter** (Martin, 1928: 1006, #5; Buikstra and Ubelaker, 1994: 79, #36): After measuring biomechanical length, note the position of midshaft (it can be marked in a nonpermanent way, such as with nonadhesive Teflon tape). Use a sliding caliper to measure the minimum distance from the ventral surface to the dorsal surface and passing through the midpoint of midshaft.
3. **Clavicular superoinferior midshaft diameter** (Martin, 1928: 1006, #4; Buikstra and Ubelaker, 1994: 79, #37): Staying at the same location, rotate the sliding caliper 90° and measure the superoinferior diameter at midshaft.
4. **Clavicular midshaft circumference** (Martin, 1928: 1006, #6): Using a flexible cloth measuring tape, measure the smallest circumference that passes through the midpoint of midshaft.

8.1.6 Clavicular Nonmetric Traits

- **Costoclavicular sulcus**: The presence and development of this sulcus, found on the inferior aspect of the sternal end of the clavicle, may be an indicator of a habitual activity. Pietrusewsky (2002: 161) suggests it indicates "activities involving repetitive rotary or back and forth motions of the shoulder." Usually scored as 0 (absent), 1 (present), or 2 (ridge).
- **Supraclavicular foramen**: Occasionally one of the branches of the supraclavicular nerve will become entrapped within the clavicle during development, exiting through a foramen on the superior aspect of the clavicle. Usually scored as 0 (absent) or 1 (present).

8.2 Scapula (Figures 8.6–8.11)

8.2.1 Anatomy (Figures 8.6–8.9)

The scapula is a large, flat, triangular bone with two basic surfaces: posterior (dorsal) and costal (anterior, or ventral). There are three borders that meet in three angles. The scapula articulates with the clavicle and the humerus.

a. The **superior** (or **cranial**) **border** is the shortest and most irregular border.
b. The **scapular** (or **suprascapular**) **notch** (or **foramen**) is a variable feature on the superior border (see Section 8.2.6). This semicircular notch is formed partly by the base of the coracoid process. It transmits the *suprascapular nerve* and may become a foramen if the ligament across its cranial edge ossifies.
c. The **coracoid process** juts anteriorly and superolaterally from the superior border of the scapula. This finger-like, blunt, rugose projection anchors a variety of muscles, ligaments, and fascial sheets important in the function of the shoulder joint.
d. The **subscapular fossa** is the shallow concavity that dominates the anterior (costal) surface of the scapula.
e. The **oblique ridges** that cross the subscapular fossa from superolateral to inferomedial are formed by *intramuscular tendons* of the *subscapularis muscle*, a major muscle that functions in medial rotation and adduction of the humerus and assists in other movements of the arm at the shoulder.
f. The **lateral** (or **axillary**) **border** is the anteroposteriorly thickest border. It is usually slightly concave.

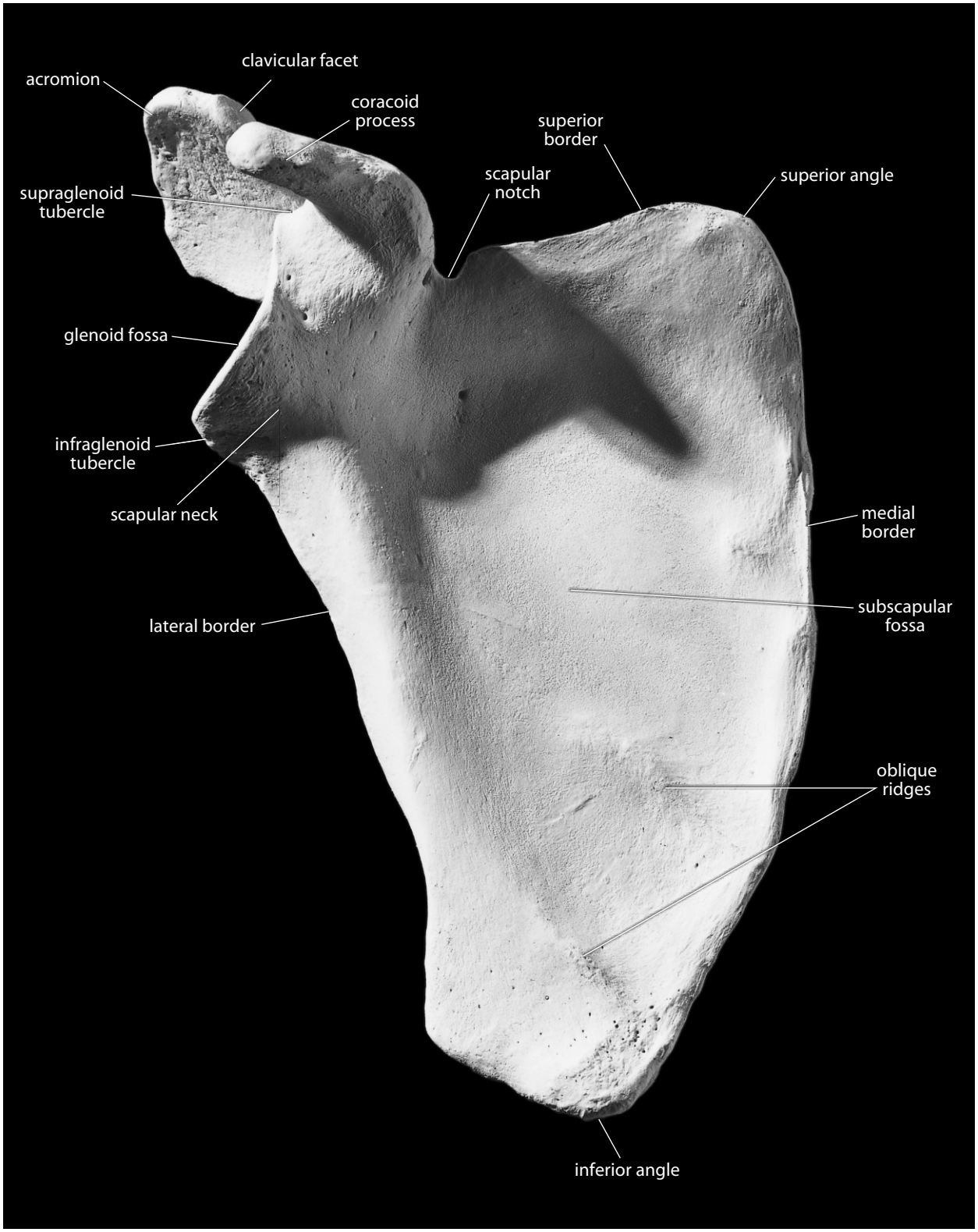

Figure 8.6 **Right scapula, anterior.** Superior is up, lateral is toward the left. Natural size.

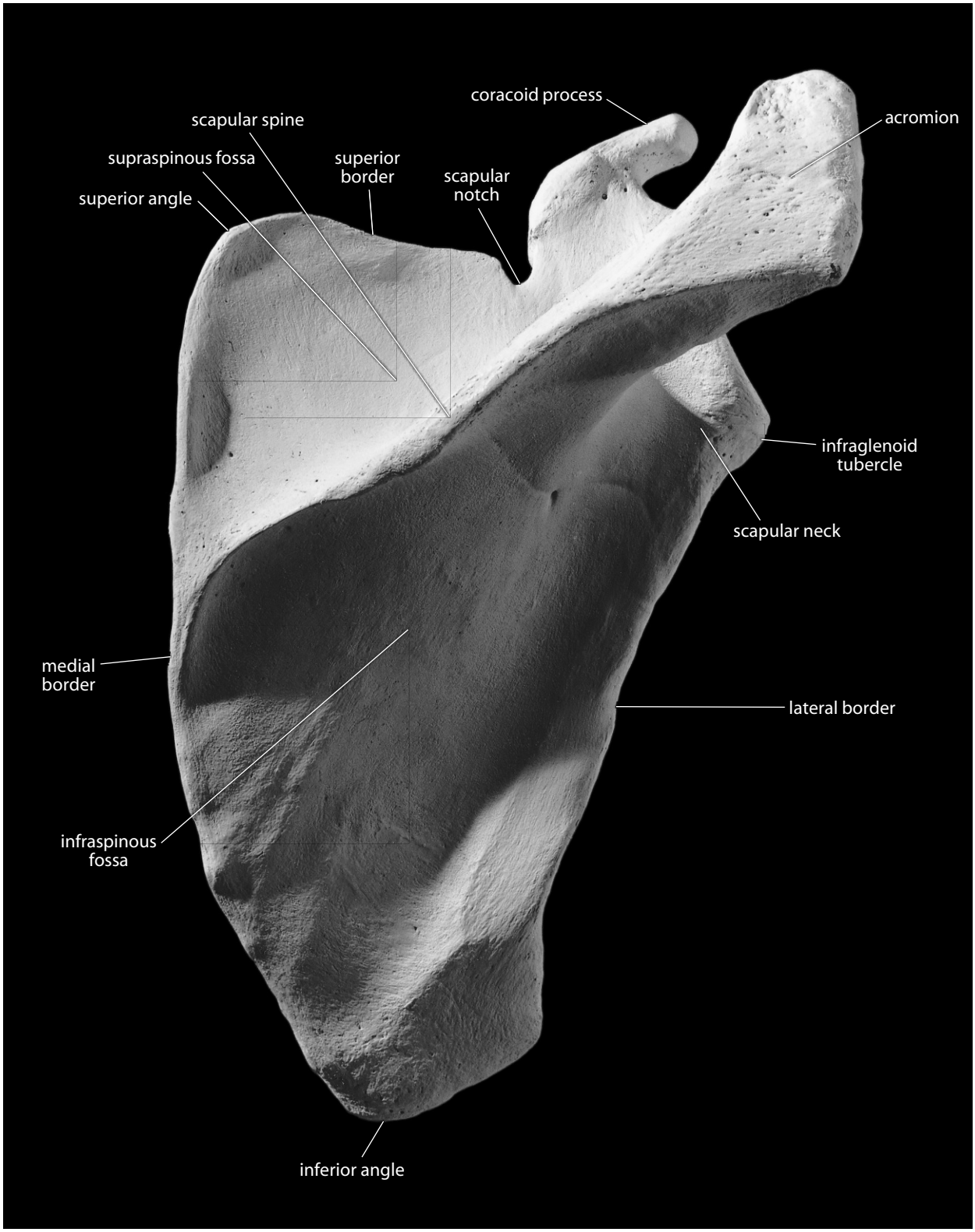

Figure 8.7 **Right scapula, posterior.** Superior is up, lateral is toward the right. Natural size.

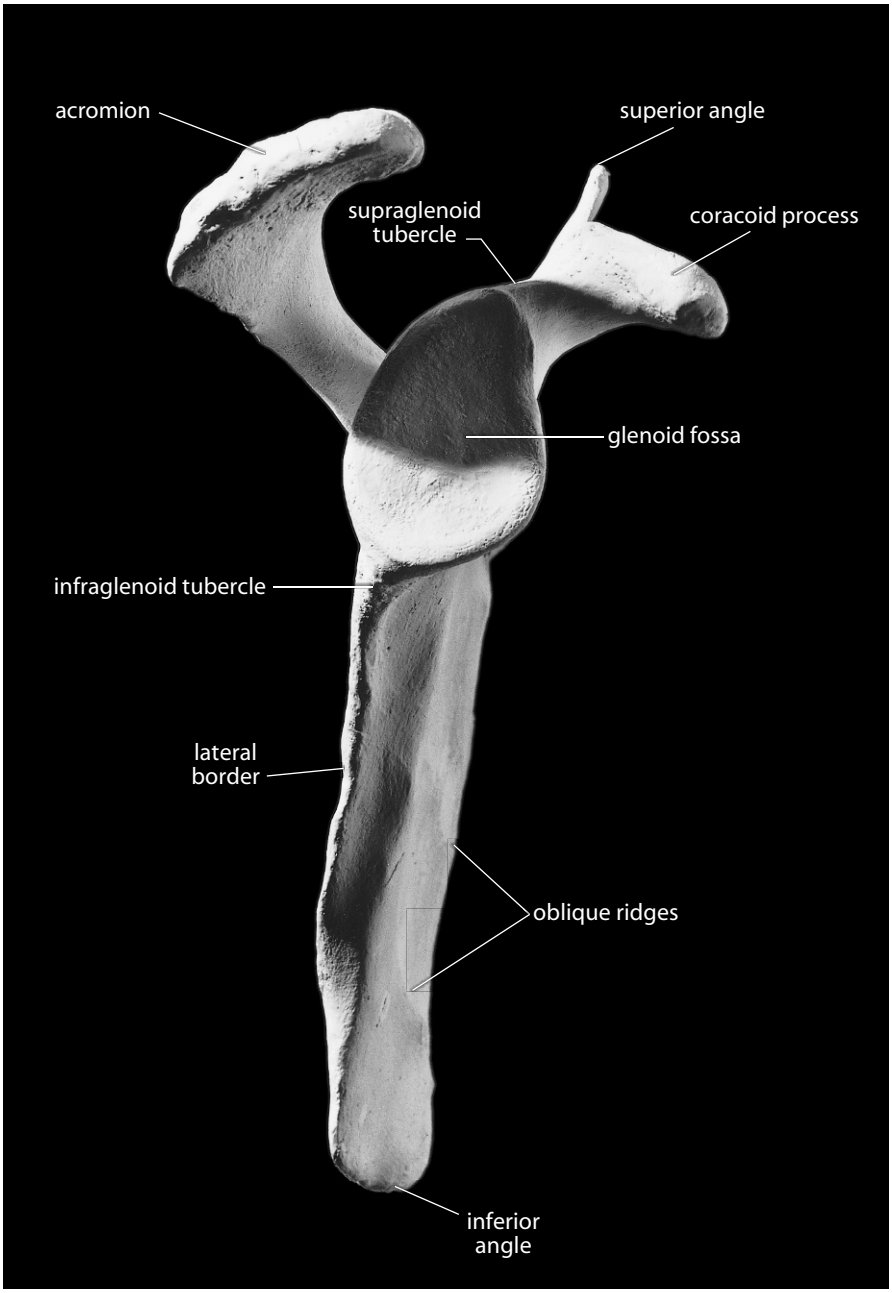

Figure 8.8 **Right scapula, lateral.** Superior is up, anterior is toward the right. Natural size.

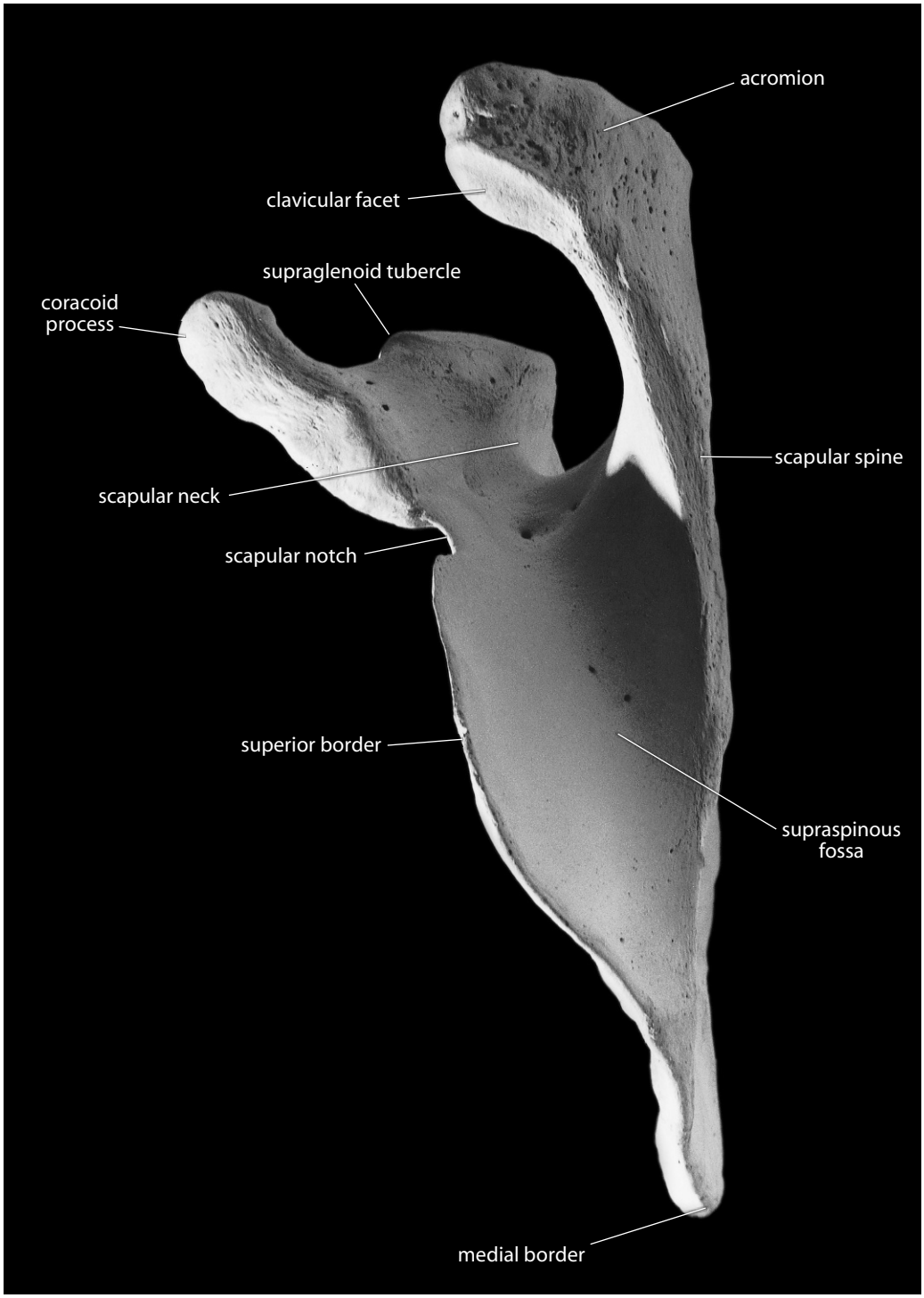

Figure 8.9 **Right scapula, superior.** Anterior is toward the left, lateral is up. Natural size.

g. The **glenoid fossa** (or **cavity**) is a shallow, vertically elongate concavity that receives the head of the humerus. The shallowness of this joint allows great mobility of the humerus (circumduction comes easily), but the shoulder joint is consequently more prone to dislocation than the hip joint.

h. The **supraglenoid tubercle** sits adjacent to the superior edge of the glenoid cavity, at the base of the coracoid process. This anchors the long head of the *biceps brachii muscle*, a flexor of the arm and forearm.

i. The **infraglenoid tubercle** sits just adjacent to the inferior edge of the glenoid fossa. It gives origin to the long head of the *triceps brachii muscle*, an extensor of the forearm and an extensor and adductor of the arm at the shoulder.

j. The **scapular neck** is the slightly constricted region just medial to the glenoid fossa.

k. The **medial** (or **vertebral**) **border** is the straightest, longest, and thinnest border.

l. The **scapular spine** dominates the posterior surface of the scapula. It passes mediolaterally across this surface, merging medially with the vertebral border and projecting laterally as the acromion process.

m. The **acromion** (or **acromial process**) is the lateral projection of the scapular spine. Its cranial surface is very rough, providing attachment for a portion of the *deltoideus muscle*, a major arm abductor whose origins continue along the inferior edge of the scapular spine. The upper fibers of the *trapezius muscle*, which act as scapular rotators, also insert here. The anteromedial corner of the acromion bears a small articular facet for the distal end of the clavicle, the **clavicular facet**.

n. The **supraspinous fossa** is the large, mediolaterally elongate hollowing superior to the base of the spine. It is the site of origin of the *supraspinatus muscle*, a major abductor of the arm.

o. The **infraspinous fossa** is the hollowing inferior to the scapular spine. This extensive, weakly concave area is the site of origin of the *infraspinatus muscle*, a lateral rotator of the arm. The intramuscular tendons of this muscle attach to the ridges on the surface of the fossa.

p. The **superior angle** of the scapula is where the superior and medial (vertebral) borders intersect. The *levator scapulae muscle* attaches to the dorsal surface of the scapula in this region.

q. The **inferior angle** of the scapula is where the vertebral (medial) and axillary (lateral) borders intersect. Rugosities on the costal and dorsal surfaces in this area mark the insertions of the *serratus anterior muscles* and origin of the *teres major muscle* from the medial and lateral borders, respectively.

8.2.2 Growth (Figure 8.10)

The scapula ossifies from two primary centers and seven or more secondary centers. One of the primary centers is for the scapular body, the other is for the coracoid process. The secondary centers are as follows: three associated with the coracoid, one with the acromial process, one with the inferior glenoid, one with the inferior angle, and one or more with the medial border. Ossification of the medial borders is variable, with elongated plates appearing and fusing during adolescence.

8.2.3 Possible Confusion

- When fragmentary, the scapula might be mistaken for the pelvis. In all of its flat parts, however, the scapula is thinner than the pelvis. Indeed, the scapular blade is mostly a single, thin layer of bone instead of spongy bone sandwiched between cortices as in the pelvis.

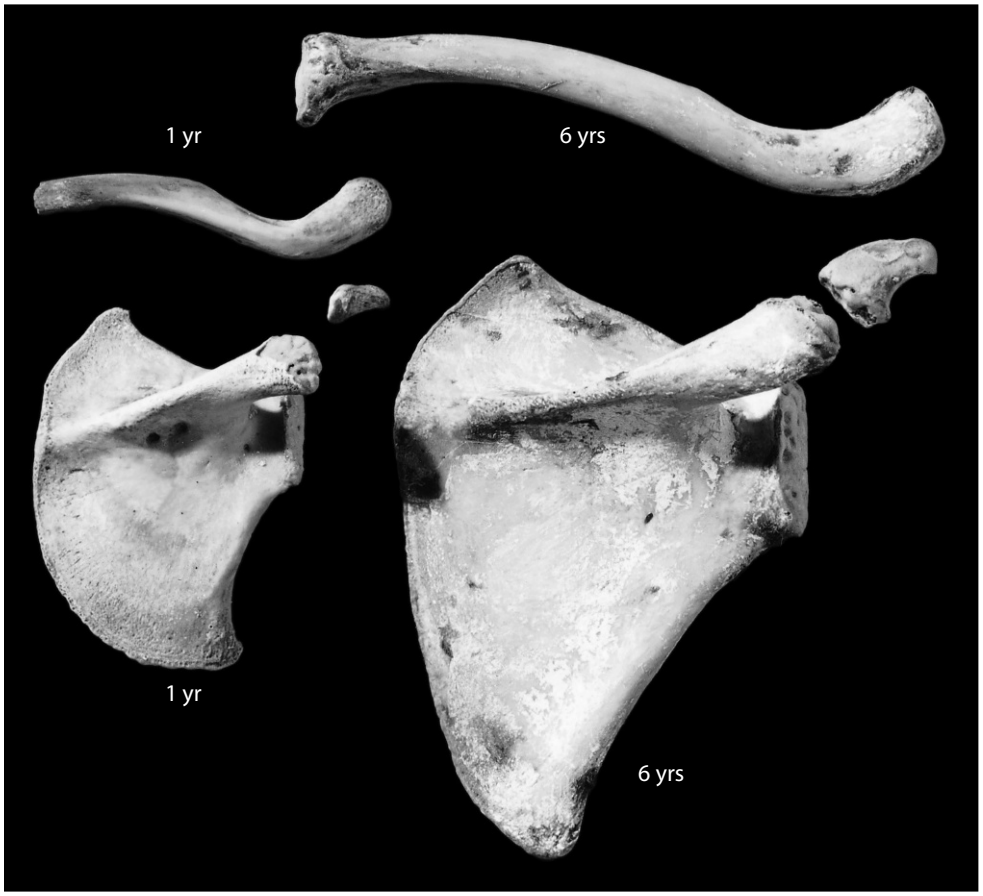

Figure 8.10 **Clavicular and scapular growth.** *Top:* Superior view of a one-year-old (*on left*) and a six-year-old (*on right*) clavicle. *Bottom:* Dorsal view of a one-year-old (*on left*) and a six-year-old (*on right*) scapula. Natural size.

- A broken fragment of the glenoid fossa could be mistaken for the hip joint (acetabulum). The glenoid fossa is much shallower and smaller than the acetabulum.
- The coracoid process could be mistaken for the transverse process of a thoracic vertebra, but the coracoid process is nonarticular.
- The lateral part of the acromial process is sometimes mistaken for a fragment of the lateral clavicle. However, because the acromion is continuous with the thin, plate-like spine, rather than a cylindrical shaft, this misattribution can be avoided. The inferior acromial surface is also smooth and concave; the distal clavicle is not.
- Tiny fragments of scapular blade or infant scapulae could be mistaken for wings of the sphenoid, but the thin bone of the scapula will be bounded by broken surfaces, whereas broken pieces of sphenoid pieces normally have free or sutural edges.

8.2.4 Siding

When intact, the glenoid is lateral and the spine is posterior. When fragmentary, use the following criteria:

- For an isolated glenoid, the fossa is teardrop-shaped, with its blunt end inferior. When looking directly into the correctly oriented glenoid fossa, note that the anterior edge of the fossa has a broad notch in it. The supraglenoid tubercle at the superior edge of the glenoid is displaced anteriorly. Posteriorly, the border of the glenoid is waisted, and the edge is raised and roughened. The anterior border is not as raised; it gently slopes into the rest of the scapula.
- For an isolated acromial process, the inferior surface of the acromion is concave and is smoother than the superior. The clavicular facet is placed anteromedially relative to the tip.
- For an isolated vertebral border, the anterior surface is concave and the posterior is convex. The oblique ridges run from superolateral to inferomedial (parallel to the scapular spine).
- For an isolated inferior angle, the anterior surface is concave, while the posterior is convex. The thickest border is lateral (axillary).
- For an isolated axillary border, the broad sulcus inferior to the glenoid parallels the border and is displaced anteriorly. The border itself thins inferiorly. The bony thickening is greatest (forming a "bar") on the anterior surface. Thickness of the cortex increases as the glenoid is approached along this border.
- For an isolated coracoid process, the smooth surface is inferior, the rough superior. The anterior border is longer. The hollow on the inferior surface faces the glenoid area (posteroinferiorly).
- For an isolated spine, the spine thins medially (vertebrally) and thickens towards the acromion. The inferior border has a tubercle that points inferiorly. Adjacent to the spine, the infraspinous fossa is most deeply excavated medially. The supraspinous fossa is most deeply excavated laterally. A variably present foramen (or foramina) perforates the scapula at the superolateral base of the spine, at the depth of the supraspinous fossa.

8.2.5 Scapular Measurements (Figure 8.11)

Measurements of the scapula are used for age determination in subadults, sex determination in adults, and are included in many multivariate analyses. The following are the most commonly taken and useful measurements of the scapula:

1. **Maximum length** (or **anatomical height** or **total height**) (Martin, 1928: 1006, #1; Buikstra and Ubelaker, 1994: 79, #38): With a sliding caliper or an osteometric board, measure the distance between the superior angle and the inferior angle.
2. **Morphological** (or **anatomical**) **breadth** (Martin, 1928: 1006, #2; Buikstraand Ubelaker, 1994: 79, #39): With a sliding caliper, measure the distance between the posterior margin of the glenoid fossa and the point at which the scapular spine intersects the medial border.
3. **Length of spine** (Bass, 1995: 122, #3): With a sliding caliper, measure the distance between the point at which the scapular spine intersects the medial border and the most distal point on the acromial process.
4. **Length of supraspinous line** (Martin, 1928: 1008, #6a; Bass, 1995: 122, #4): Using a sliding caliper, measure the distance between the point at which the scapular spine intersects the medial border and the tip of the superior angle.
5. **Length of infraspinous line** (Martin, 1928: 1008, #5a; Bass, 1995: 122, #5): Using a sliding caliper, measure the distance between the point at which the scapular spine intersects the medial border and the tip of the inferior angle.
6. **Scapular index** (Martin, 1928: 1009; Bass, 1995: 122): (anatomical breadth ÷ anatomical height) × 100.

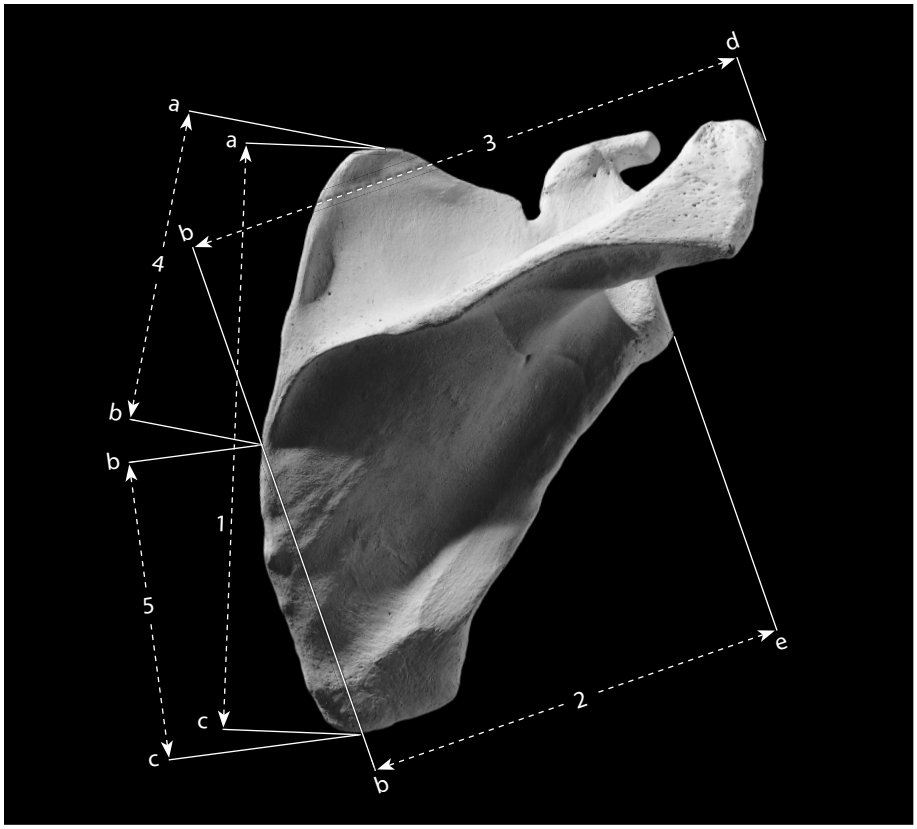

Figure 8.11 **Scapular measurements.** One-half natural size.

Locations: a) superiormost point of superior angle; b) intersection of scapular spine and medial border; c) inferiormost point of inferior angle; d) point on acromion farthest from 'b'; e) posterior margin of the glenoid fossa.

Measurements: 1) maximum length; 2) maximum breadth; 3) length of scapular spine; 4) length of supraspinous line; 5) length of infraspinous line.

8.2.6 Scapular Nonmetric Traits

- **Suprascapular foramen or notch form**: Occasionally, the suprascapular ligament bridging the suprascapular notch will ossify, forming a suprascapular foramen. Usually scored as 0 (absent), 1 (notch), 2 (foramen), 3 (spur/notch), or 4 (large concavity).
- **Circumflex sulcus**: A groove on the posterolateral border of the scapula that bisects the area of insertion of the *teres minor muscle*. Varies in size and depth; may be broad and shallow. Usually scored as 0 (absent) or 1 (present).
- **Unfused acromial apophysis** (or **os acromiale**): This epiphysis will occasionally persist as a separate bone in adulthood. Usually scored as 0 (absent) or 1 (present).
- **Humeral** (or **acromial**) **facet**: A facet on the inferior surface of the acromion, possibly activity-related. Usually scored as 0 (absent) or 1 (present).
- **Acromion shape**: Note the shape of the outline of the acromion. Usually scored as 1 (rectangular), 2 (triangular), 3 (sickle-shaped), or 4 (irregular).

- **Vertebral border**: Note the shape of the outline of the vertebral border. Usually scored as 1 (convex), 2 (concave), 3 (straight), or 4 (irregular).
- **Inferior angle shape**: Note the shape of the outline of the inferior angle. Usually scored as 1 (V-shaped), 2 (blunt), or 3 (rounded).

8.3 Functional Aspects of the Shoulder Girdle

Because the glenohumeral joint between the scapula and humerus is free to move as the scapula moves, and because the shoulder girdle has only one bony connection to the thorax, the upper limb of a human is far more mobile than the lower limb. In contrast to the shoulder, the hip joint is fixed in relation to the vertebrae. In the glenohumeral joint, there is a great disparity between the large articular surface of the humeral head and the smaller glenoid surface. This provides further mobility to the arm because the ball-shaped humeral head can rotate in any direction in the glenoid fossa. The capsule of the glenohumeral joint is ligamentous and muscular (and relatively weak), and the shoulder is therefore an easily dislocated joint.

Actions of the shoulder girdle are accomplished, for the most part, by muscles inserting on the scapula. The scapula moves, sliding and rotating on the back, in response to muscle contractions that change the orientation and position of the glenoid. One of the major scapular rotators is the *trapezius muscle*, which originates from the nuchal line of the occipital and the spines of cervical and thoracic vertebrae. The *trapezius muscle* inserts on the scapular spine, acromion, and posterosuperior lateral clavicle. The contraction of its various parts can therefore elevate, suspend, stabilize, and rotate the scapula. The *serratus anterior* works with the *trapezius,* inserting along the medial edge of the scapula's costal surface. Contraction of the lower fibers of this muscle can therefore rotate the scapula, with the opposite rotation produced by the *rhomboid major muscle*.

In all, 16 muscles affect movements of the shoulder. The scapula is a sort of mobile foundation for muscles that move the arm. The scapula itself can be moved so that the glenoid faces different directions. Muscles anchored on this mobile platform in turn move the arm via the shoulder joint. A few large, superficial muscles cross both the shoulder and elbow joints and can effect movement there.